The Galileo/Mars Observer/Ulysses Coincidence Experiment

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From March 21 to April 11, 1993 the Galileo, Mars Observer and Ulysses spacecraft were tracked in a coincidence experiment, searching for low-frequency (~millihertz) gravitational radiation. In the spacecraft Doppler technique, the earth and a distant spacecraft act as separated test masses. The relative dimensionless velocity (change in velocity divided by the speed of light) between the earth and spacecraft is continuously monitored with a high-precision Doppler tracking system of NASA's Deep Space Network. A gravitational wave incident on this system is replicated three times in the time series of fractional Doppler frequency (i.e., relative velocity) with amplitude proportional to the gravity wave amplitude and replication pattern dependent on the angle the gravitational wavevector makes with the earth-spacecraft line. The Galileo (GLL) observations were made with an S-band (2.3 GHz) radio link, the Ulysses (ULS) observations with a hybrid S-band uplink/S-X band downlink (X band - 8.4 GHz) , while the Mars Observer (MO) data were X-band up- and downlink. The three experiments thus had unequal sensitivity to the principle noise sources (tropospheric and plasma scintillation noises) . The sun-earth-spacecraft angle and two-way light times were also unequal, giving rise to different plasma noise levels, different responses to a wave coming from a given point on the celestial sphere, and different Fourier passbands.

This GLL/MO/ULS experiment is the only low-frequency coincidence experiment to date. Very strong suppression of systematic effects that were not common-mode in the three time series was possible. In this talk I will discuss the sensitivity of the experiment, analysis approaches for burst, background, and periodic radiation, some of the problems encountered, and some implications for the very-sensitive Ka-band (-32 Ghz) gravitational wave experiment using the Cassini spacecraft.